cludes by detailing the analysis and reduction methods in the frequency, time, and amplitude domains.

Chapter 8 presents modal analysis (MA) as an important tool in studying mechanical vibration. MA, although new, is based on a number of older techniques (mobility, mechanical impedance, etc.). The theoretical basis of MA makes extensive use of linear multi-degree-of freedom (MDOF) systems in either undamped or damped condition. The most prominent excitation signals are (*a*) sinusoidal (discrete stepped sine, slow sine sweep), (*b*) periodic (*c*) random (periodic and pseudo random), (*d*) transient (impact, chirp, and burst random). The frequency response function (FRP) matrix of a system can be pictured by (*e*) Bode plot, (*f*) Nyquist or Argand diagrams, and (*g*) real part versus frequency plus imaginary part vs frequency. Care must be taken when exciting the structure by either an impactor, hammer, electromagnetic, or electrohydraulic shakers. The modal parameter extraction methods for SDOF can be (*h*) circle-fit (*i*) peak amplitude (*j*) inverse. The more complicated MDOF can be obtained by (*k*) frequency domain (lightly damped), (*l*) time domain (curve fit on the impulse response function). The final phase of most curve fitting procedures is superimposing the measured FRF curve on the "theoretical" one and applying the extracted modal parameters. Extreme care is required for MA work.

Chapter 9 explains and identifies structural parameters. The book explains the half power band width extraction, effect of an uneven power spectral density (psd) input, resulting statistical errors, and a very brief mention of the difficulty in assessing closely spaced modes. For the ambient vibration analysis in time domain, the structural system can be modelled by the ARMA method. Statistical accuracy of structural parameters can be accomplished by computing the Cramer-Rao and the maximum likelihood (ML) methods. The Prony or Fourier methods would be most applicable for transient vibration analysis. Transfer functions can be obtained by time series and complex exponential approaches in the time domain. The order of the system can be gotten by the AIC method.

Chapter 10 covers two applications of parametric time series modeling methods encompassing fault conditions in an automobile engine production assembly line. A Kullback-Leibler dissimilarity method is perused in the time series analysis which is the nearest neighbor classification rule method. The AR and MA are time series used. Computational methods are explained for both stationary and nonstationary time series. The second system is a multiple scalar-output (MISO) source identification scheme. The MISO models are (*a*) Bendat (multivariable spectral analyses), (*b*) ARMA (rational polynomial transfer function), and (*c*) multivariate AR model. Windowed periodiagram spectral analysis is compared to the AR model. Evidence suggests that the multivariate AR model is superior to the windowed periodiagram spectral analysis.

Chapter 11 reports on machine tool wear. The need for monitoring is great due to false alarms in tool wear, proper tool life, and need to reduce production costs. The available tools are (*a*) laboratory tools [measuring miscroscopes and/or scanning electron microscope (SEM)], (*b*) on-line (electrical resistors or flank radioactive tracers, proximity sensors to the tool). Vibration analysis is employed since it has the potential capability of responding to excitation occurring at inaccessible locations in the tool. The two prime processing schemes are (*a*) filter (high or band pass), (*b*) envelope detection phase. The frequency time pattern trends can be identified by Campbell diagram. The trend index (TI) correlates well with tool wear and could be a good candidate for monitoring scheme. The author applies this to milling and shows how this can be accomplished by vibration monitoring.

Chapter 12 considers MSA applied to turbulent flow. The latter occurs in combustion and turbomachinery. Measurements are made using a laser Doppler velocimeter (LDV) and is a high pass filter. As stated by the author, "The most significant low frequency noise results from aerodynamic sources." The book points out two approaches in computing digital processing of a single LDV burst. They are (*a*) Doppler frequency determination by a direct zero crossing technique, and (*b*) utilization of an advanced algorithm, i.e., Fourier transform or discrete auto-correlation function.

In summary, this book "toes the mark." The reviewer would have preferred seeing an expanded section on Z transforms, flutter of aircraft wings, and turbine blades. Additional topics would be the vibration analysis in a rig of a complete row of rotating blades attached to a disk plus modal analysis of a bladed row, their problems and results. The Campbell diagram of rotating bladed row including engine order would be an asset to the book. The reviewer does recommend this book to those interested in learning about MSA as well as the experienced. Compliments to the authors and editor!

**Advanced Fracture Mechanics,** M. F. Kanninen and C. A. Popelar, Clarendon Press-Oxford University Press, New York, N.Y., 1985, 563 pages.

**Reviewed by H. Saunders**

This is a full-fledged book on fracture mechanics. It covers the present state of the art in a very comprehensive and concrete manner. It begins with the fundamentals and steps gingerly along to the more advanced aspect of dynamic and elastic-plastic fracture mechanics. As stated by the authors, "We wrote this book believing that fracture mechanics is at a unique stage. Enough research has been performed to provide a solid foundation upon which future progress will build. At the same time society dictates for optimum uses of energy and materials are increasingly forcing structural integrity assessments to be made in the more realistic way afforded by fracture mechanics approach." This magnificent volume addresses the subject from the applied mechanics viewpoint and shows its proper coherence with metallurgy. Fracture mechanics can be stated in another manner, i.e., it is an engineering discipline that clearly states the conditions where a load bearing body can be subjected to failure caused by the enlargement of a dominant crack in that body.

The book consists of 9 chapters and an appendix.

Chapter 1 introduces the subject and presents an overview. The initial topic is a short discourse on current fracture mechanics and applications. This covers relationship between fracture mechanics and strength of materials, linear fracture mechanics relationships, damage tolerance assessments, and code requirements (ASME codes). This continues with origin of fracture mechanics, beginning with Griffith theory and stress intensity factor definition. This projects into the aspect of subcritical crack growth, rapid crack propagation and touches upon probabilistic fracture mechanics (Weibull's law). Nonlinear considerations stem from the COD approach, "J" integral, strip yields models, instability theory, and criteria for crack growth in nonlinear conditions. The concluding section shows the need for understanding the thermal shock problem, degraded nuclear plant piping, and the leak before leak condition. This chapter can be considered as a summary of what's to be forthcoming.

Chapter 2 delves into elements of solid mechanics. It considers the analysis of stress and strain and their complementary equations, theory of elasticity, energy principles, potential and complementary potential energy plus principle of virtual work. This follows with viscoelasticity of linear thermal bearings of simple material and elastoplasticity (yield criterion, deformation plasticity, and elastic-viscoplasticity). Chapter 3 deals with linear elastic fracture mechanics (LEFM) and considers linear elasticity tip fields plus stress intensity factor (closed form solution and more recent methods). The chapter continues with the "J" integral, energy release rate, additional invariant integrals (Knowles and Sternberg) plus others and the path independent I integral. The plastic zone, fracture toughness relations, and plane stress fracture plus the R curve relation conclude the chapter.

Chapter 4 highlights dynamic fracture mechanics. The authors stress the continuum based (material to be continuous). Pioneers in this endeavor are Mott (extended Griffith theory by including kinetic energy and assumed $dv/da=0$), Roberts and Wells, Berry and Dulaney et al. who corrected Mott's approach. Additional efforts were expended in crack branching. Later work covered the mathematical investigation of elastodynamic fracture mechanics, crack arrest, and nonlinear aspects of fracture mechanics. The authors continue with a full blown derivation of elastodynamic crack tip fields and energy release rate. Analysis of laboratory specimens and study of crack propagation used in fracture mechanics are considered. They are (*a*) DCB (double cantilever beam), (*b*) DT (double torsion specimen), (*c*) axial crack propagation in a pressurized pipeline, (*d*) steady state crack propagation, and (*e*) strip yield models. The chapter concludes with the study of crack propagation, experimentation, dynamic crack propagation analysis, crack growth interaction with dynamic loading.

Chapter 5 is an eye-opener on elastic-plastic fracture mechanics (EPFM). Due to limitations of LEFM, the need to include influence of significant plastic deformation leads to increased development in EPFM. The initial attempt in modeling plastic deformation was instituted by Dugdale. This follows anti-plane, elastic plastic solutions for Mode III. This continues with solution of plastic crack tip fields, based on a two-dimensional field. Present results have shown that J integral has become the preferred fracture characterization parameter due to the ease of computation and is quite simple in measuring the crack tip opening displacement. Further mathematical efforts tempered by experiments, consider the fully plastic solution plus the estimation technique, hardening failure assessment diagram. This leads to J integral testing based on a single measured load displacement record proposed by Rice. ASTM suggests a standard test method (E813) for determining $J_{ic}$ (plane strain value of J at initiation of crack growth). The chapter ends with a full blown discussion of J controlled crack growth and extended crack growth. They stress the importance of J integral and its variants.

Chapter 6 explains the fracture mechanics models for fiber reinforced composites. Since composites are anisotropic, the field of anisotropic fracture mechanics opens up. The micromechanical approach is the favored one at present but still the analysis is wrought with some problems. Related topics include fracture of adhesive joints.

Chapter 7 speaks about time dependent fracture. This stems from the application of a suddenly applied constant stress which produces an instantaneous elastic strain followed by a slow continuous straining or creep. Two competing mechanisms are involved in creep crack growth. Creep deformation is characterized by crack tip blunting in the material ahead of the crack tip. This tends to retard crack tip growth due to relaxation of crack tip stress field. The other mechanism involves an accumulation of creep damage in form of microcracks and voids that enhance crack growth as they coalesce. Important aspects of crack tip fields are (*a*) elastic-secondary creep, (*b*) elastic-primary creep, (*c*) primary secondary creep (secondary creep zone developing near crack tip), (*d*) plastic-primary creep (sudden applied load; sufficient to induce instantaneous plastic strain in a cracked body), (*e*) plastic-exponential low creep (stationary crack under Mode III loading). The next set of topics consider creep crack growth. The important considerations are (*f*) elastic-secondary creep crack fields (Mode I loading of a crack extending in an elastic-power low creeping material), (*g*) steady-state crack growth (small scale yielding for Mode I), (*h*) transient crack growth (difficult to estimate), and (*i*) elastic-primary creep crack fields (based on an extensive set of experiments performed by a number of researchers). One believes that $C^*$ (energy rate integral) correlates better with crack growth rate than the stress intensity factor for creep crack growth correlation. Models for crack growth in viscoelastic materials have mainly concentrated in linear material behavior. They are an extension of Dugdale's yielded stress model. There is great need for a nonlinear growth theory for viscoelastic materials.

Chapter 8 covers some nonlinear aspects of fatigue crack propagation. Most of LEFM in fatigue is of an empirical nature. This considers the constant-amplitude fatigue crack growth relation (Paris' law and its variants). The second is Miner's law which ignores load interaction. The next concept in crack closure is due to Elber (crack closes and prevents further propagation and is tensile by nature). Budiansky and Hutchinson propose a theoretical model used in examining Elber's concept. Kanninen and coworkers have improved the concept employing a steady state crack propagation model. Another important subject is fatigue crack growth eminating in and around welds. Work has been done using FE calculations. Due to large disparities, inelastic deformation must be incorporated in determining crack propagation in welding. The final chapter recounts the sources of information in fracture mechanics. It includes a list of technical journals, conference proceedings, standards, dissertations, handbooks, treatises (volume assembled by Prof. Leibowitz), and textbooks.

This book covers fracture mechanics in a very lucid and comprehensive manner and contains a number of topics not found in other texts. It is a masterpiece in fracture mechanics and should appeal to the tyro and expert on this subject. The reviewer would have preferred seeing the following incorporated in the book. They are (*a*) table explaining the symbols, (*b*) cross reference for the tremendous number of authors, and (*c*) incorporate more information on fracture mechanics from a probabilistic fatigue point of view. Nevertheless, the reviewer highly recommends this book. Bravo to the authors!

**Vibration of Engineering Structures**, C. A. Brebbia, H. Tottenham, G. B. Warburton, J. M. Wilson, R. R. Wilson, Springer-Verlag, Berlin and New York, 1985, 300 pages, $21.00 (paperback).

**Reviewed by H. Saunders**

This book is based on course notes and given by a number of instructors. This volume does possess cohesiveness. There is good continuity from one chapter to another. The book does not falter in any place. The book is based on a week's course given at Southampton, England. As cited by the editors, "The increasing size and complexity of new structural forces in engineering have made it necessary for designers to be aware